



Elemental Composition of Commercial Titanium and Zirconia Dental Implants



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Background

Titanium and zirconia (Y-TZP and ATZ) are currently the materials of choice for dental implants. With increasing knowledge of biocorrosion processes and possible immunological reactions, research interest in the material composition of dental implants has revived. Although dental implants are widely used, little is known about their exact elemental composition and impurities. The present study aimed to conduct a state-of-the-art elemental analysis of commercial titanium and zirconia dental implants to specify their elemental composition and identify contaminants.

Methods

Fifteen commercial titanium dental implant systems from twelve manufacturers and nine commercial zirconia dental implant systems from eight manufacturers were chemically processed and analyzed using inductively coupled plasma-mass spectrometry (ICP-MS) and optical emission spectrometry (ICP-OES).

Titanium	CAMLOG	Conelog Screwline Promote Plus	Ti Grade IV
		Camlog Progressive Line Promote Plus	Ti Grade IV
	BEGO	Semados SC 58174	Ti Grade IV
	MEDENTIS MEDICAL	ICX-Premium	Ti Grade IV
	NOBEL BIOCARE	NobelActive Internal RP	Ti Grade IV
		NobelActive TiUltra RP	Ti Grade IV
	STRAUMANN	SLActive Standard Implant	Ti Grade IV
		ROXOLID Slactive IMPLANT BL Tapered Loxim	85% Ti 15% Zr
	SIC INVENT	SICace Screw Implant	Ti Grade IV
	ASTRA TECH / DENTSPLY SIRONA	OsseoSpeed TX	Ti Grade IV
	ANKYLOS / DENTSPLY SIRONA	Ankylos C/X Implant	Ti Grade II
	MIS IMPLANTS / DENTSPLY SIRONA	C1B-13420	Ti-6Al-4V-ELI
	NEODENT / STRAUMANN	Helix GM	Ti Grade IV
	OSSTEM IMPLANT	USII SA	Ti Grade IV
	THOMMEN MEDICAL	SPI Contact RC Incell	Ti Grade IV

Zirconia	STRAUMANN	PURE Ceramic Implant (Monotype)	ZrO ₂ (Y-TZP)
		Material sample (disk)	
	AXIS BIODENT / CAMLOG	CERALOG® Monobloc Implant	ZrO ₂ (Y-TZP)
		Material sample (implant-shaped)	
	BREDENT MEDICAL	whiteSKY™ Zirconium Implant	ZrO ₂ (Y-TZP)
		Material sample (disk)	
	DENTALPOINT / ZERAMEX	Zeramex® P6 Implant	ZrO2 (ATZ- HIP®)
		Material sample (cylinder)	
		Zeramex® T ZERALOCK Implant	ZrO2 (TZP-A-BIO-HIP®)
	Z-SYSTEMS	Z5m(t) Implant	ZrO2 (TZP-A Bio-HIP®)
		Material sample Zirkolith® (disk)	
	MOJE KI / MEDENTIS	ICX-Active WHITE Implant	ZrO ₂ (Y-TZP)
		Material sample (disk)	
	VITA / VITACLINICAL	ceramic.implant CI	ZrO ₂ (Y-TZP)
		Material sample (disk)	
	MOJE KI / SDS SWISS DENTAL SOLUTIONS	SDS 1.1 Implant	ZrO ₂ (Y-TZP)
		Material sample (disk)	

Table 1: Investigated Implant Systems/Samples

Manufacturer/vendor and implant system names as present in the European market. (Y-)TZP=(yttria-stabilized) tetragonal zirconia polycrystals; ATZ=alumina toughened zirconia; ZrO₂=zirconium dioxide; HIP= hot isostatic postcompaction; ELI=extra low interstitials



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Fig. 1

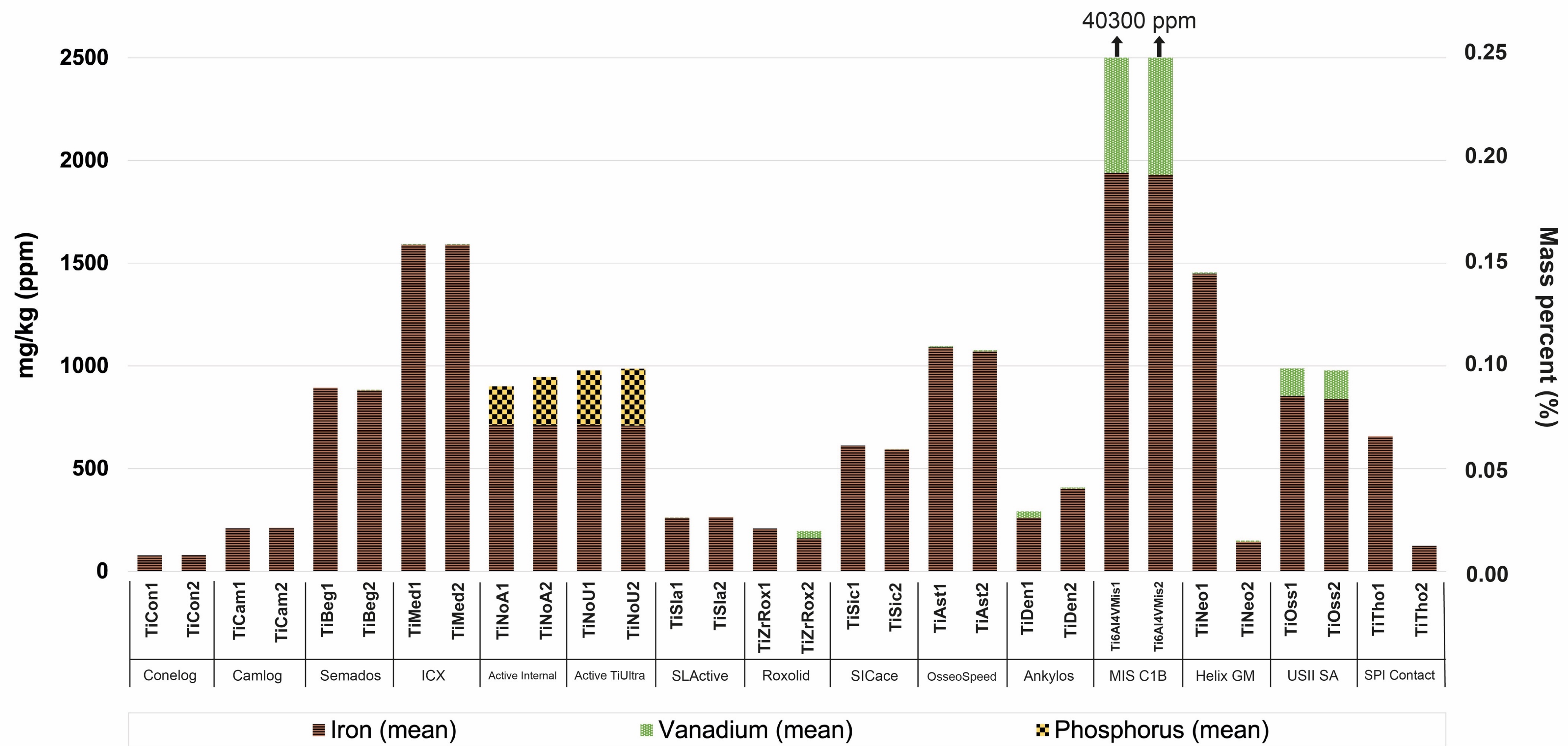


Fig. 2

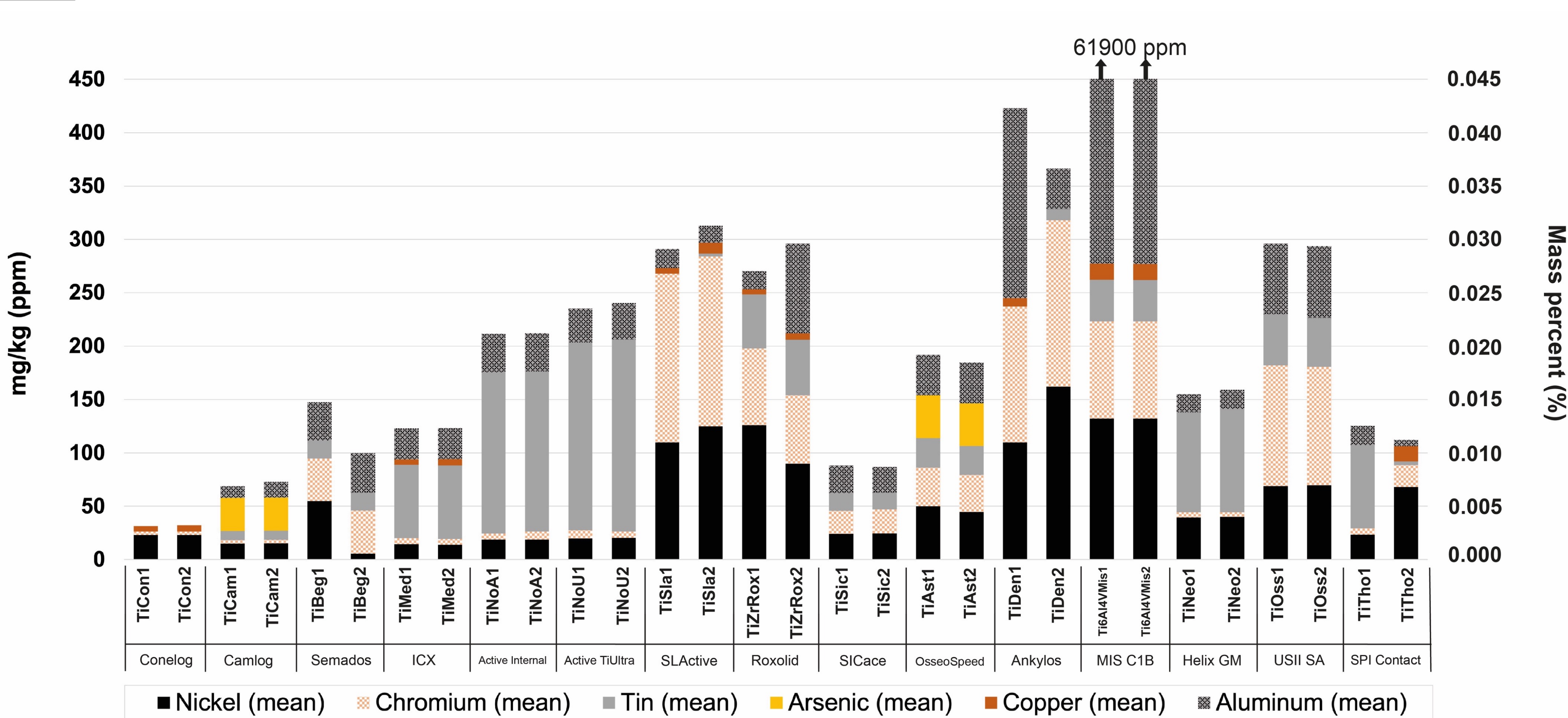


Fig. 3

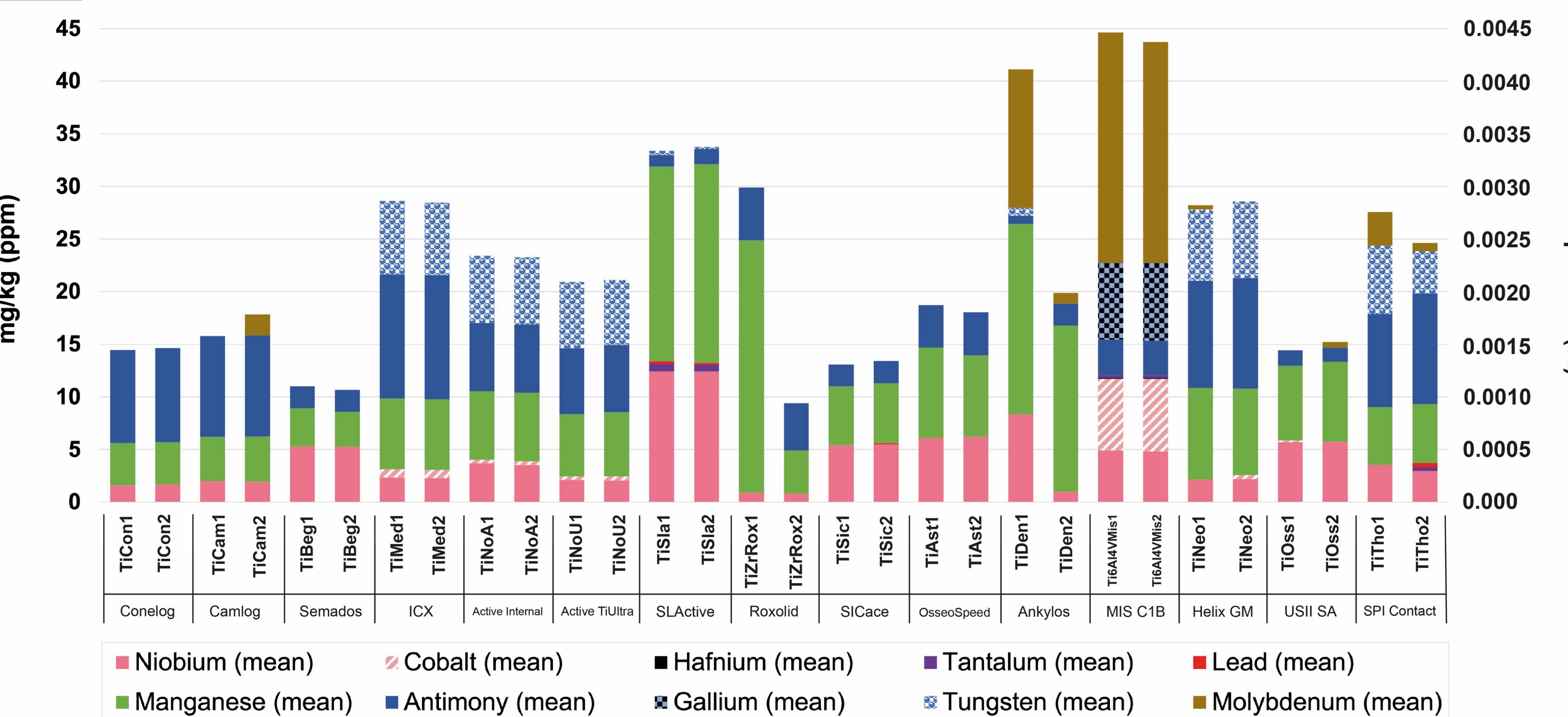
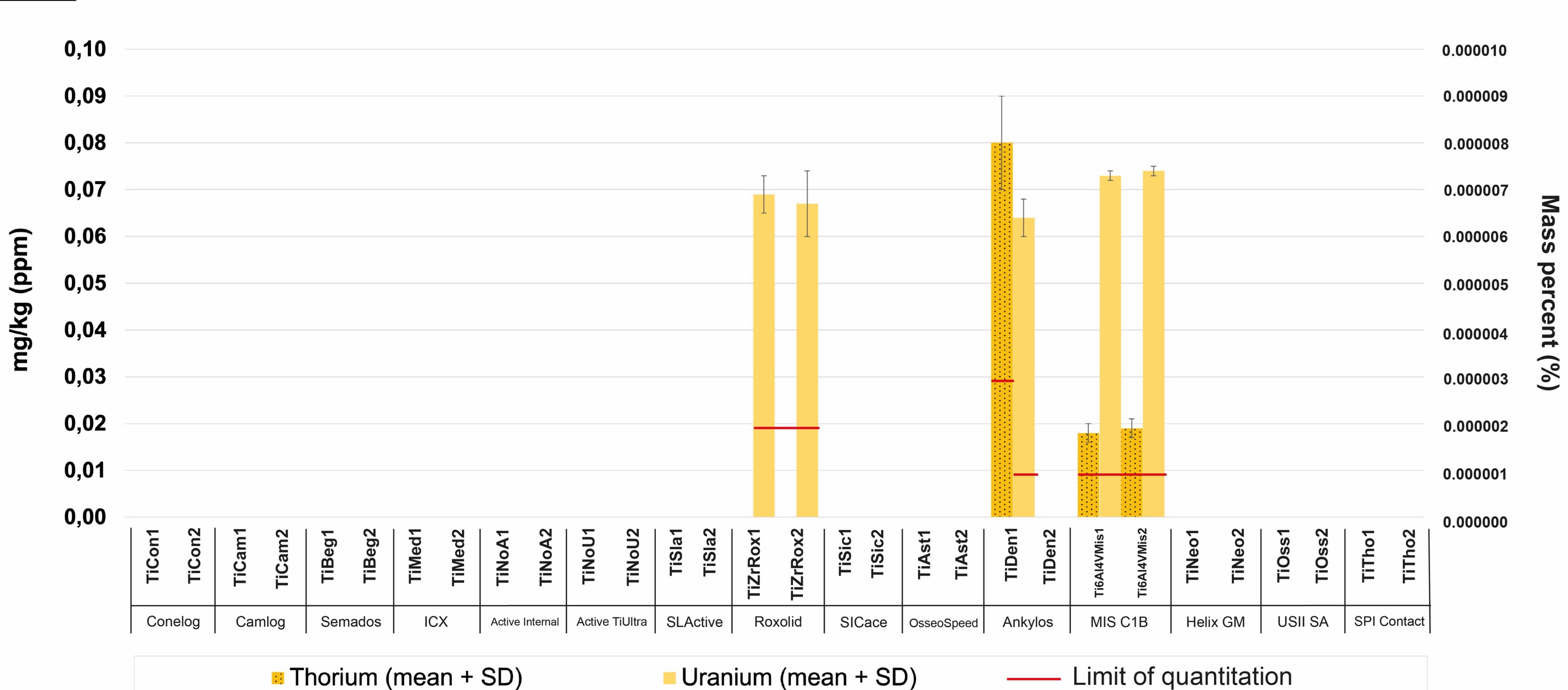
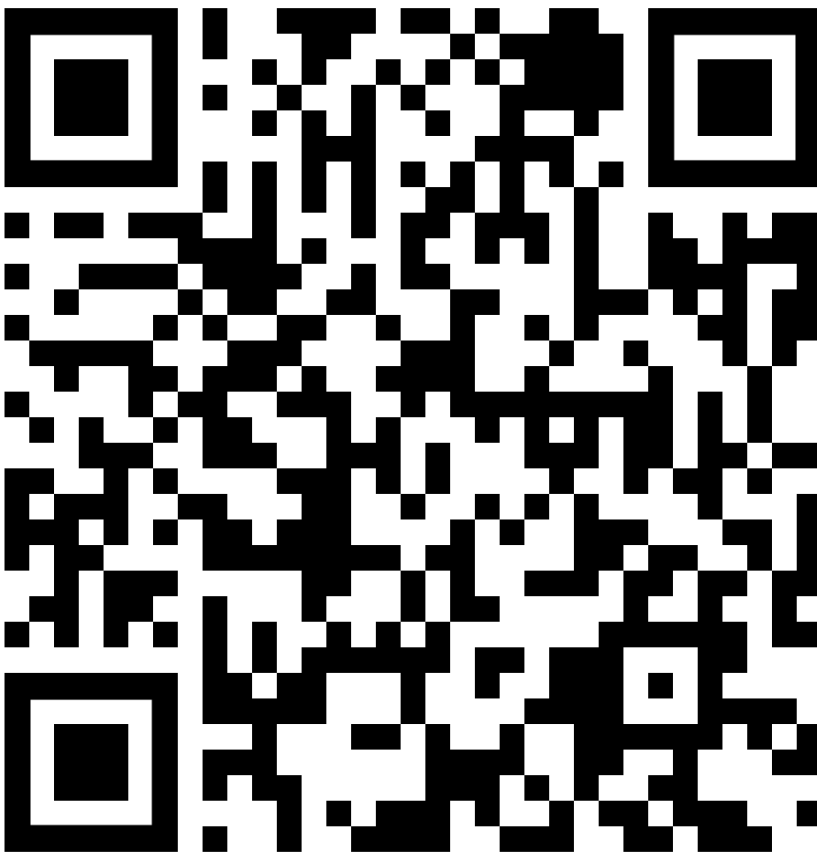


Fig. 4



Stricker A, Bergfeldt T, Fretwurst T, Addison O, Schmelzeisen R, Rothweiler R, et al. Impurities in commercial titanium dental implants – A mass and optical emission spectrometry elemental analysis. Dental Materials. 2022;38:1395-403. <https://doi.org/10.1016/j.dental.2022.06.028>



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Fig. 5

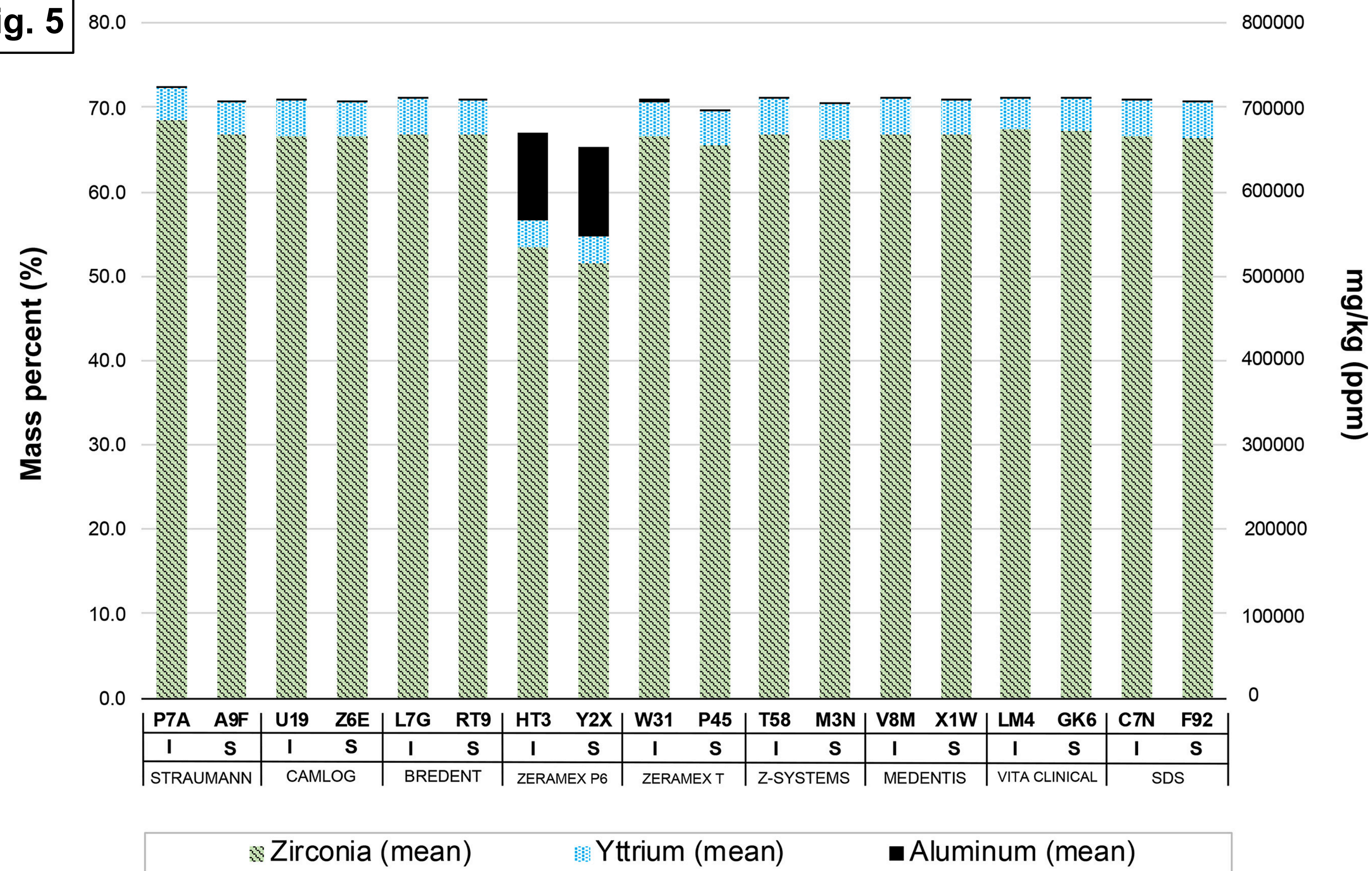


Fig. 6

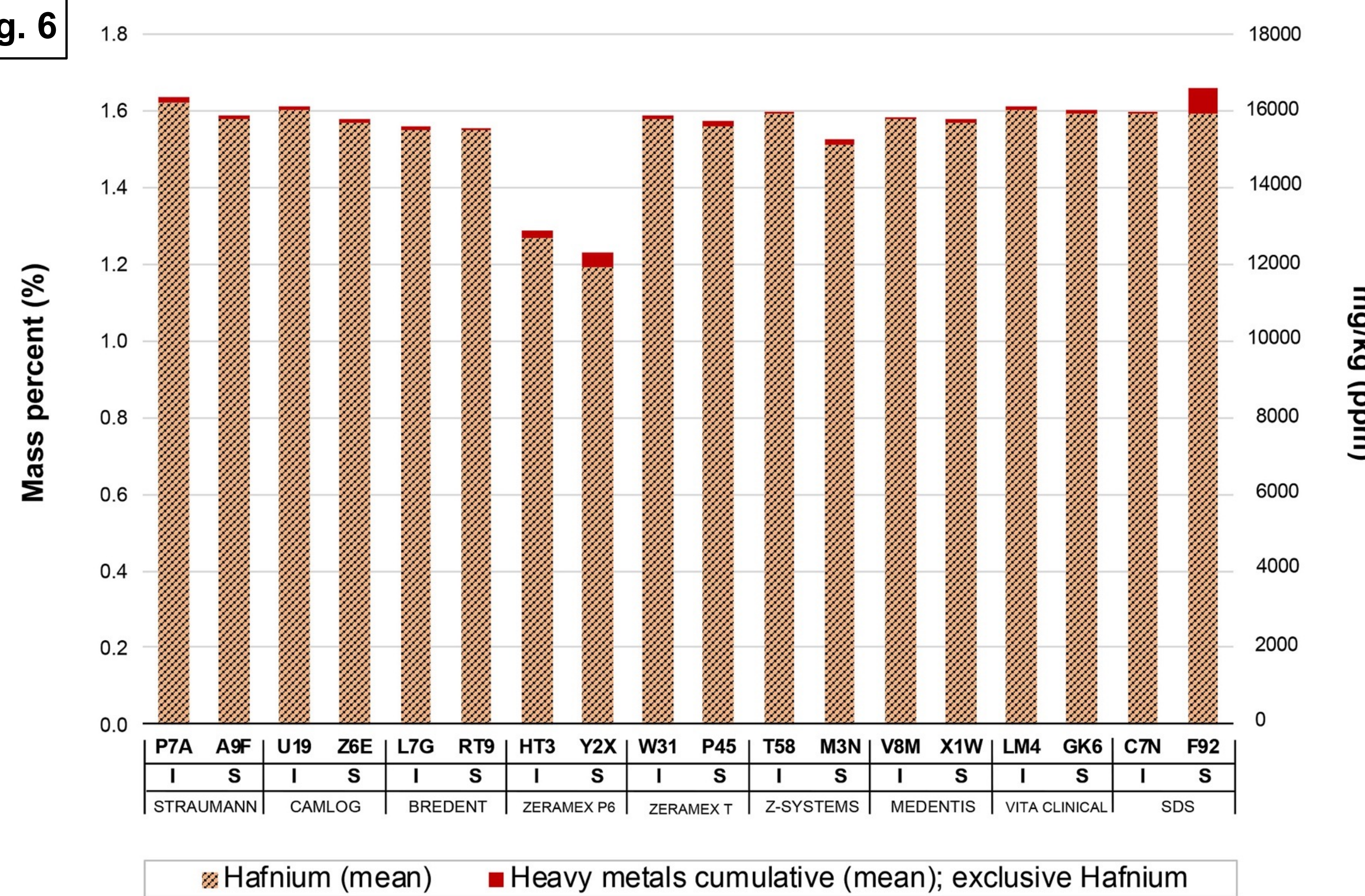


Fig. 7

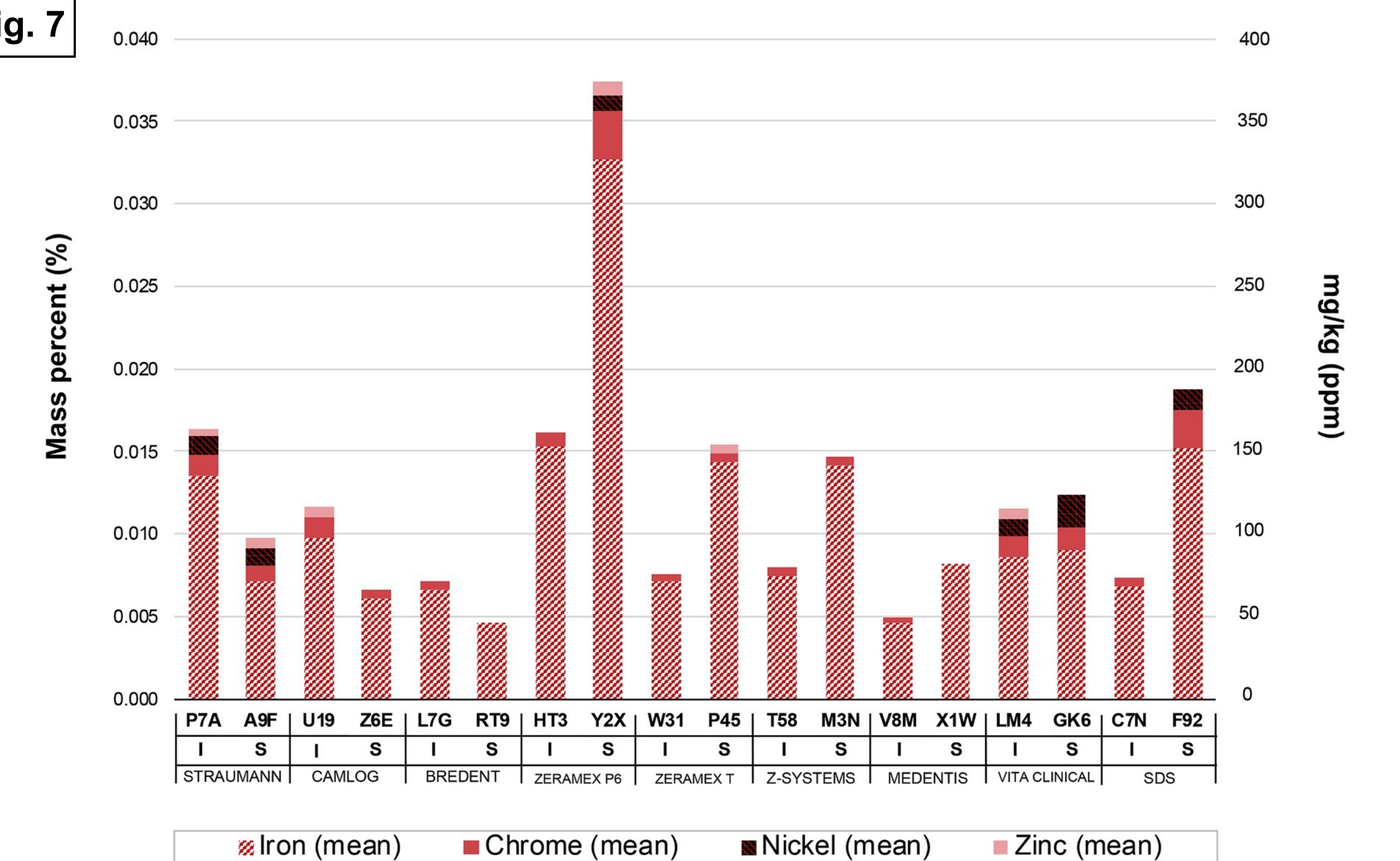
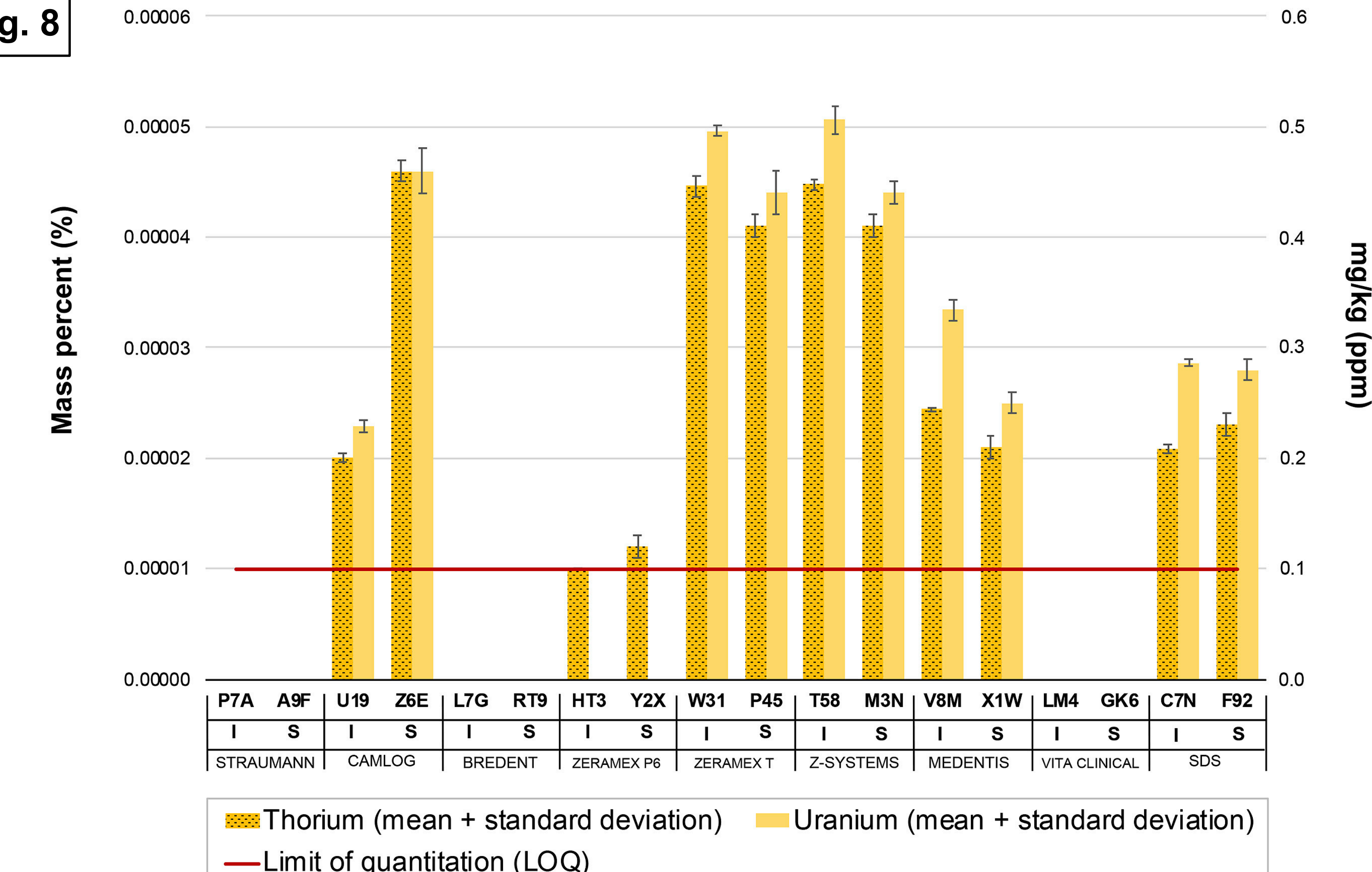
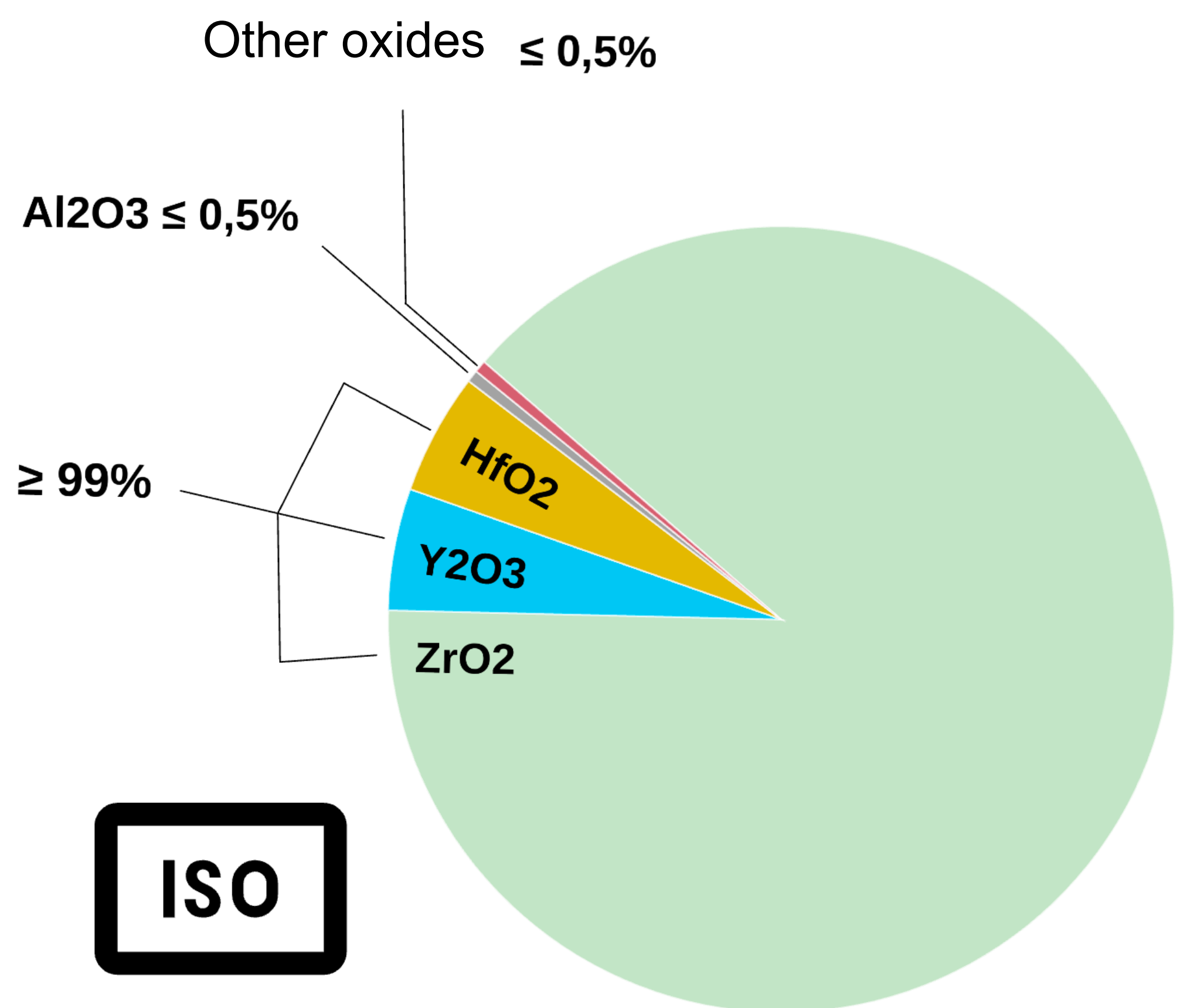


Fig. 8



Gross C, Bergfeldt T, Fretwurst T, Rothweiler R, Nelson K, Stricker A. Elemental analysis of commercial zirconia implants - Is "metal-free" devoid of metals? J Mech Behav Biomed Mater. 2020;107. <https://doi.org/10.1016/j.jmbbm.2020.103759>



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Results

- All titanium and zirconia dental implants were in conformance with the respective ISO/ASTM standards or manufacturer data.
- All implants investigated contained exogenous metal contaminants, including potentially noxious metal elements (e.g., Ni, Cr, As) to a variable extent.
- Ultra-trace level contamination with the radionuclides U-238 and Th-232 was found in most zirconia implants and a fraction of the titanium implants.

Conclusion

- **Commercial titanium and zirconia dental implants are not devoid of contamination with various metal elements.**
- **Since there are differences in the degree of contamination between the implant systems and manufacturers, a certain impurity fraction seems technically avoidable.**
- **An adaptation of industry standards should be discussed to provide a biomaterial as pure as technically possible to the patient.**
- **From an elemental point of view, zirconia dental implants cannot be considered 100% “metal-free”.**



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